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INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

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SIGNIFICANCE OF THROW-AWAY PACKAGING FOR WATER PROTECTION AND AIR HYGIENE

*By Dr. H. E. Vogel, * Manager of the Schweizerische Vereinigung für Gewässerschutz und Lufthygiene (VGL), Zürich*

It was still believed in the forties that water pollution could be overcome by means of mechanical purification. It was soon found, however, that biological purification was necessary; nowadays a third, chemical stage is often added. Further difficulties are caused by the constantly increasing amounts of sludge originating in sewage-purification plants.

It was also believed at first that domestic garbage might be disposed of by simple tipping. Efforts were then made to compost such waste in a proper manner; later on it became necessary to burn noncompostable materials. Industrial refuse, oily sludge, radioactive waste, carcasses and condemned meat, car wrecks, and many more items today belong to the refuse of modern industrialized society.

The latest development in the consumer-goods market, which in the very near future is likely to cause much trouble to those responsible for water protection and air hygiene, is the introduction of throw-away packaging.

The Swiss public first took note of this problem when Dr. Fritz Kutter, Director of the Coordinating Body of the Swiss Beverage Industry, Zurich, published an article in the Neue Zürcher Zeitung of 9 June, 1966, on the subject "Throw-away or Returnable Bottles? The Throw-away Bottle, a Requirement of the Trade." Although only part of the problem was discussed in this article, it could nevertheless be understood how threatening the refuse-disposal situation would become within a few years.

The Swiss Association for Water Protection and Air Hygiene (VGL) carried out an investigation in 1967, in order to clarify all aspects of the problem of throw-away packaging. Some important results given in the final report are presented here.

Completely new living habits have been acquired nowadays. The extensive motorization of large sections of the population has brought in its wake picnic places, camping grounds and construction of vacation bungalows in regions which sometimes are situated far from the beaten track. On the other hand, present living standards, which often can be financed only by instalment payments, increasingly oblige married women to take up employment. Thus, only the short leisure time is available for preparing meals and doing the housework. Although in many trades the working week has been shortened, modern man has less and less time available and therefore generally welcomes any laborsaving service offered by the consumer industries.

On the other hand, many new products with special properties have been developed, in accordance with the requirements of modern nutrition, e.g., edible oils with low melting points, which in their turn require novel packaging. The tendency no longer to manufacture products with a long service life, since greater profit can be obtained with short-lived fashionable novelties, has made itself felt also in the packaging field. Shortage of personnel in the consumer-goods sector has

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contributed greatly to promoting the use of throw-away packaging; the importance of this factor increases with rising wages.

This is the reason why self-service shops have had such surprising success first in the USA and then in Europe. This tendency first began with packaging. Jams, soluble coffee, honey, pickled fruit and vegetables, and ready-to-eat salads have been available in Switzerland in throw-away packages for many years; this has now been extended to baby food, yoghurt, milk, cream, and rea -to-eat meals. Only beginnings of this development can be observed in the beverage sector.

Throw-away bottles are those which are paid for by the consumer and thrown away after their contents have been removed; so far, consumers only paid a deposit for returnable bottles.

Dr. Kutter states that in 1966 over 1.5 billion bottles were filled with various beverages and marketed. This corresponds to the transportation of approximately 0.8 million t glass and 1 million t beverages. A 25% reduction in the weight of glass is possible if light-weight glass and throw-away bottles are adopted. However, 500,000 t additional glass bottles would have to be produced, requiring an equal amount of raw material.

Introduction of throw-away packaging for milk and yoghurt led to the use of new materials, like paper and plastic, for packaging liquid foodstuffs. Glass bottles for oil and vinegar, which pass from the filler to the grocer, to the consumer and back, were replaced a little later by plastic bottles and cans that can easily be thrown away.

Obviously, trade is interested in throw-away packaging, whether it be plastic bottles or tin cans. In the case of returnable bottles an unsatisfactory situation is created through the extra work for cashiers, sorting in retail stores, returning to the central store, washing of bottles and glasses, inventory checks, and large space requirements.

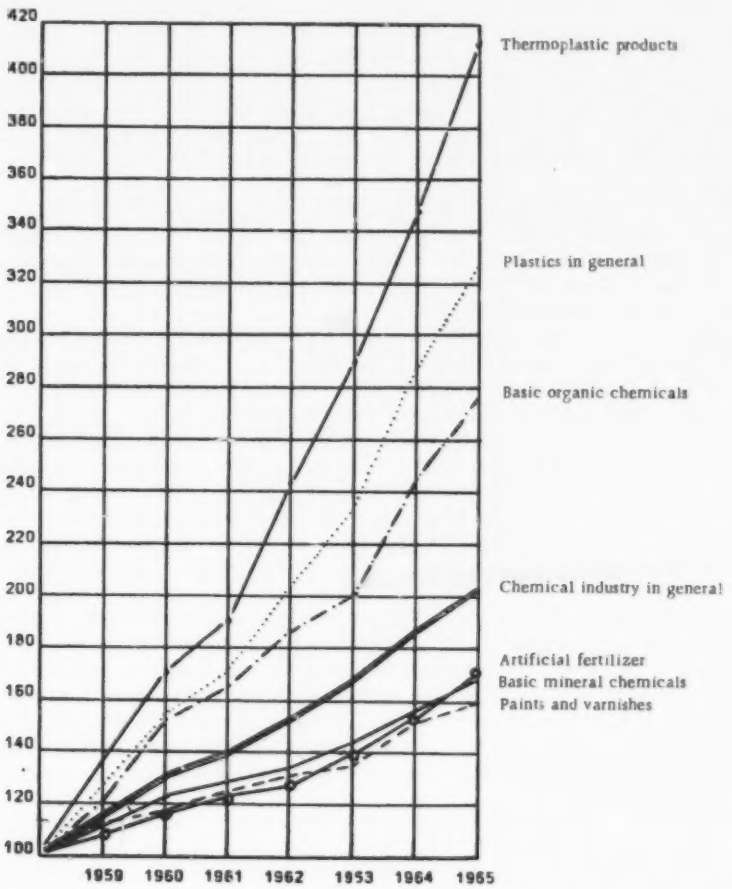
Throw-away bottles, irrespective of their material, are more economical for the traders than returnable bottles. Depending on the product and the kind of processing, the packaged end product is more expensive to the filler when throw-away packaging is used.

Until the beginning of 1967 it was assumed by experts that plastic bottles could not be used for carbonated beverages, e.g., mineral water, most soft drinks, and beer, since the pressure would necessitate the use of thick-walled containers which could not compete in price with glass bottles. Introduction of bottles made of hard PVC seems to be imminent for such beverages.

Consumers often show great dissatisfaction with present marketing trends. Although the throw-away packing often relieves the consumer of work, price increases are frequently unavoidable when it is introduced. Vance Packard in the USA showed already in 1960 that the yearly bill to be paid by Americans for the attractive packaging that they are enticed to buy amounts to about 25 billion dollars. This is solely the price of the packaging and wrapping. If this figure is divided by the number of families in the USA, the result will show that the average American family today spends 500 dollars per year purely on packaging.

Producers of consumer goods as well as the general public usually ignore the fact that in the case of war in near or distant foreign countries the supply of raw materials for consumer goods and their packaging may be interrupted. This risk is considerably increased when throw-away packaging is adopted. Returnable glass bottles constitute a circulating stock, additional production being necessary only in order to cover increased demand and replacements. Throw-away packaging, however, usually is destroyed after being used once. Plastic materials employed nowadays cannot be used again, although the return of such plastics in the case of war is contemplated in the USA. Increasing use of plastics would cause serious deficiencies in Swiss supplies in the case of war, which could not be overcome

easily, since both the required raw materials and the machinery for their production would be lacking.



Development of the chemical industry and its different branches in Western Europe: 1958 = 100

A report published by the OECD in Paris, in summer 1967, under the title "L'industrie chimique," indicates that basic organic chemicals show the largest growth within the chemical industry. Amongst them plastics have the highest rate of growth; thermoplastic materials, in particular, are in the lead: between 1958 and 1965 their growth amounted to 415%. Further intensive progress can be predicted if their growth curve is extrapolated. The cause of this development may be that certain plastic raw materials, e.g., for PVC, have for several years been produced at low cost by the petrochemical industry. The large number of oil refineries helps to maintain this tendency.

The following quantities of packaging and auxiliary materials were consumed in the German Federal Republic in 1965: 4,070,560,000 DM worth of paper and cardboard; 1,889,835,000 DM worth of metal; 1,275,920,000 DM worth of plastics;

40,004,000 DM worth of glass; 297,694,000 DM worth of timber; 44,078,000 DM worth of textiles; 18,900,000 DM worth of soft rubber; 3,060,000 DM worth of ceramics.

The international market price of plastics varies inversely with consumption. The following growth of the total production of plastics is predicted: 1970, 30,000,000 t; 1975, 65,000,000 t (thus quantitatively attaining the level of world steel production); 2000, 150,000,000 t.

Subdividing world production of plastics, we obtain the following percentages: polyolefins, 20 to 23%; polystyrenes, 12 to 14%; PVC and copolymers, 22 to 24%; phenoplasts, 8 to 10%; polyester and epoxy resins, 11 to 13%; aminoplasts, 5 to 8%; all others, 12 to 16%.

The following is known about the distribution of plastics production over the different consumer sectors: some 44,000 t plastic raw materials were produced in Switzerland [in 1965?], of which 29,000 t were exported. Our country imported 107,000 t in the same year so that the total consumption of plastics in Switzerland may be assumed to have been 122,000 t.

Whereas until 2 to 3 years ago the total PVC production was based on acetylene, Messrs. Lonza of Lalden near Visp today produce PVC by petrochemical methods, so that 30% of [the requirements for] this material are now produced in Switzerland. Throw-away packaging absorbs 15% of the plastics produced.

Polymerization is the most widely used method for the synthesis of thermoplastic materials. The monomer gaseous or liquid nuclei combine to form chain molecules, "unsaturated" double bonds being severed without foreign matter being split off. Polymerization is controlled by adding regulating agents and interrupted by inhibitors when the required molecule size has been attained. Production of plastics involves the use of auxiliary substances, e.g., emulsifiers, catalysts, accelerators, etc.

Processing of plastics also frequently involves the use of auxiliary substances, e.g., stabilizers, separating agents, and antioxidants, which are retained in the plastics partly in the form of decomposition products. Auxiliary substances such as softening agents, protective agents against aging, ultraviolet-ray absorbers, antistatics, paints, pigments, etc., are also added to the plastics in order to obtain certain properties. The plastics then have to be freed from excess additives. This is achieved by aeration or in vacuum in the case of volatile substances; otherwise the plastic material is leached.

Polyethylene, PVC, and polystyrene, are widely used; teflon, ABS, nylon, PVA, saran, epoxides, polysulfon, and other polyolefins follow in second place. Fifty new kinds of polymers will appear on the market within the next three or four years, but only 20% of them at the most will prove marketable.

Consumers generally do not know what a questionable boon this is. Leaching and venting of the toxic auxiliary substances causes water and air pollution. The quantitatively predominating PVC is most dangerous from the long-term aspect due to its high content of chlorine and phosgene. Teflon (polytetrafluoroethylene) is increasingly used nowadays; its high fluorine content may cause hazards to inanimate nature, plants, animals, and human beings.

A so-called positive list of additives is now being prepared in Switzerland. These are harmless additives used in the production of plastics for packaging purposes. The relevant article in the constitution was passed by the government on 10 November 1964. However, problems of water protection and air hygiene, arising from the elimination of plastics additives, are not considered.

The Council of Europe has carried out investigations of domestic and industrial waste in the countries belonging to it, whose total number of inhabitants is 300 millions. At a basic figure of $^{3}/_{4}$ t refuse per 1,000 inhabitants/day, the total amount of refuse produced during a year is 82,125,000 t. It is estimated that this

figure will increase by 50% during the next 10 to 15 years, due to rising living standards and population increases.

On the other hand, the specific weight of refuse has considerably decreased in many countries, due to the increasing content of plastics. While the total weight of refuse has remained constant in these countries, its volume has almost doubled.

According to Dr. Kutter, we shall face a very serious situation in a few years as regards throw-away glass bottles. At that time in the future 500,000 t throw-away bottles will have to be disposed of.

At present 170 kg refuse are produced per inhabitant/year in Zurich; the 10 kg glass contained therein are insignificant. However, a radical change-over to throw-away bottles, produced mainly by the glass industry, would require 300 additional bottles to be smashed yearly per head of population. Thus the amount of garbage would almost double and nearly half of it would consist of glass.

Replacement of glass by PVC at 25 g per bottle would necessitate the use of about 36,000 t PVC for the required 1.5 million bottles. Since PVC contains 55% chlorine, incineration of these bottles would release into the atmosphere 20,000 t pure hydrochloric acid, unless this is eliminated by industry.

Throw-away packaging poses the following problem for refuse-disposal plants: one trash can per household is often insufficient nowadays. With increasing use of throw-away packaging, refuse collection would have to be considerably extended. Many of the existing refuse-incineration plants are already overloaded and cannot take up the rapidly increasing quantities of refuse. A special problem is posed by the need to tip the clinker from garbage-incineration plants.

In the early sixties the BASF Ludwigshafen conducted experiments in a special plant with mixtures, quantitatively differing in composition, of BASF refuse, domestic garbage, and waste oil. The following emission values are permissible in accordance with VDI guidelines VDI-2106 "Maximum Immission Concentration (Mac) — Hydrochloric Acid" and VDI-2108 "Maximum Immission Concentration — Sulfur Dioxide," and the "Second Regulation for Carrying out the Law for Protection against Immissions (Establishment and Operation of Refuse-Incineration Plants)" of 24 June 1963:

dust — 150 mg/m^3 STP at 7% CO_2;

hydrochloric acid — 4 g HCl/m^3 STP at a measured initial concentration of 0.35 mg HCl/m^3 in the surroundings;

sulfur dioxide — 1 g SO_2/m^3 STP at a measured initial concentration of 0.33 mg SO_2/m^3 in the surroundings.

The emission of the experimental plant mentioned was considerably lower than the permissible limits. However, today, 5 years after the tests, the rapid development of throw-away packaging has caused a much higher content of PVC and other noxious substances in the incinerated refuse, not to mention the flood of plastics that will be encountered in a few years.

The competent department of the Swiss Institute for Material Testing (EMPA) states that the hazards caused by chlorine compounds to incineration plants, in particular to their grates, are proven. Short-time as well as long-time surface limits have to be determined for hydrochloric acid and chlorine. The long-time limit depends on the threshold up to which no harm is done to the population; the so-called danger limit is two orders of magnitude higher. Scientists have been using the so-called mac-value for 100 years; this is the maximum immission concentration at which workers may stay at their jobs for eight hours without endangering their health. Damage to plants may be the first indication of a health hazard. The so-called mic-values which are one to two orders of magnitude larger than the mac-values, are determined by such damage to plants.

The following measures may be taken in order not to exceed the mic-values:

prohibiting the emission of the gases considered;

changing the process, either as regards raw material or as regards technique; should this be impossible then by

providing installations for reducing the noxious waste gas.

Mostly, however, such installations cannot be provided economically.

Waste gas may be diluted by: blowing fresh air into the chimney; this consumes energy and does not attack the trouble at its source, since the total emission remains the same; providing tall chimneys; the waste gas is delivered to greater heights with more lift and higher turbulence. Mic-values lasting only for hours may have serious consequences in residential quarters if the waste gas reaches surface inversions at heights of 20 to 200 m. Immissions lasting for days may cause damage to industry if the waste gas stays in inversions at heights of 200 to 500 m.

Phosgene, which occurs together with PVC, attacks mucous membranes and air alveoli in the lungs. This has been observed in Geneva.

The scientific data on air hygiene, required when planning refuse-incineration plants, may be obtained from EMPA and from the Aerological Station of the Central Meteorological Institute in Payerne.

The former checks the combustion processes, the quantities of crude gas, the temperatures, and the emitted quantities of gas. The latter carries out the required meteorological tests and on the basis of data supplied by the supervising authority may offer suggestions on the height of the chimney.

It is the opinion of the [Swiss] Federal Institute for the Distribution and Maintenance of Water Resources and Purification of Sewage (EAWAG) at the Federal Technical University (ETH) that if domestic refuse is to be composted and not incinerated, its glass content (i. e., disregarding industrial and commercial refuse) will probably increase two- or threefold with the introduction of throw-away bottles. Nevertheless, collection, removal, and processing of the refuse will still be possible under tolerable conditions. The problem is different in principle in the case of large-scale suppliers of glass waste, e.g., industry, trade, hotels, restaurants, canteens, and foodstuff wholesalers. The quantities of glass to be expected from this sector after introduction of the throw-away bottle must, according to EAWAG, be kept out of municipal refuse collection and processing.

The Swiss Department of the Interior considers that the [Swiss] Federal Laws on Water Protection provide a legal basis for effectively countering any developments that might cause general water pollution.

Waste glass is considered ballast material in composting, incineration, and tipping, and thus presents no direct danger to open water and groundwater. Nor will burning of PVC bottles at present cause direct water pollution through immissions. Hence, no special regulations have been introduced, so far, with respect to the disposal of bottles and packaging material.

However, there can be no doubt that the private-economy problem of efficiency is passed on to the public, since staff and plants for refuse disposal have to be increased constantly in order to dispose of the continuously increasing amounts of refuse.

From the aspect of water protection, all measures should be favored that are intended to prevent the unlimited increase in the amounts of domestic and industrial refuse and to exclude from commerce all incombustible waste or substances that are difficult to decompose and might pollute water either directly or indirectly.

The Swiss Department of the Interior is of the opinion that sooner or later it will be necessary to find ways and means to direct the constantly increasing flood of glass into the proper channels. We primarily refer to the need to obligate suppliers of beverages, edible oils, and other liquids to take back glass containers; such contractual undertakings already exist between the Bülach Glass Factory and its big customers.

The [Swiss] Federal Authorities consider that contractual undertakings should be aimed at extensively and prompted officially, even at the risk of no refund being allowed for the returned glass but an acceptance fee having to be exacted instead. Should this measure, aimed at keeping towns and water clean, cause additional expenses, these would probably have to be added somehow to the production costs.

Attempts should also be made to induce suppliers of packaging materials to promote development of chlorine-free and sulfur-free plastics; this, however, may be difficult to attain in view of the rapid growth of PVC production.

As far as disposal of throw-away packaging is concerned, we are in a difficult position inasmuch as the various sectors of the economy at their different levels, with different forces and leverages, must contribute to the maintenance of an equilibrium which at present is very labile.

Our national economy certainly requires competitive Swiss production as well as an efficient consumer-goods organization. The consumer has the undisputed right to optimum fulfillment of his requirements. However, this must not cause a weakening of our economic defense and, most important, the requirements of water protection and air hygiene must not suffer in any way.

We need detailed information on the situation in the consumer market and on incipient trends to enable us to plan refuse-disposal plants. On the other hand, producers and distributors must be accurately informed on the negative effects of certain market developments, especially the effects of the growth in the sector of throw-away packaging on water protection and air hygiene; their legal and financial obligations must be clearly indicated.

This probably implies that the various interested circles will have to be represented in a coordinating body, that the entire problem will have to be studied at university level, and that possibly a new course of studies, concerning marketing policy with regard to water protection and air hygiene, may have to be established.

DETERMINATION OF THE OXYGEN REQUIREMENT OF MATURING COMPOSTS

By Dr. P. Chrometzka, *
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Saarbrücken. Director: Prof. Dr. H.-D. Wulff

Maturing refuse compost, with or without the admixture of sewage-sludge, has a high oxygen requirement. The usual means of controlling it are insufflation, provision of air ducts in the windrows (Rohde, 1957; Spohn, 1962) and other similar methods to increase the amount of available oxygen. Spohn and Kneer (1968) lately investigated the breathing of various ripe composts, resorting to CO_2 determinations in order to obtain data on the breathing.

The writer investigated the oxygen requirement of maturing composts with the aid of a Warburg apparatus (type SL 85 by Braun, Melsungen), measuring the direct oxygen requirement in mm^3 per hour. One-gram doses of a thoroughly mixed compost sample, obtained from various German refuse-composting plants, were introduced in reactors, into whose median insert were pipetted 0.5-ml doses of a 10-percent KOH solution to absorb the evolved CO_2. The determinations

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were made parallelly in two samples. To simulate natural conditions, the compost samples were used in the same state as taken from the windrow. Less mature composts mostly had a 40 to 50-percent water content, which was lower in more mature composts. The writer also determined the oxygen requirement at constant water content, to establish the dependence of breathing on water supply in progressive ripening. Finally, the investigations also included compost samples that had been preserved for 6 months at a 5-percent water content and then brought up to a 60-percent water content. These rehumidification tests were aimed at establishing how quickly the breathing started anew with such samples and whether more serious damage was done to the microorganisms decomposing the compost mass. The degree of maturity of a compost was established by means of the Verticillium cinnabarinum-test developed by the writer (1968). This fungus test makes it possible to establish the degree of maturity of a fermenting compost mass after 36 to 48 hours, by determining the growth inhibition of Verticillium cinnabarinum in composts of varying degrees of ripeness.

TEST RESULTS

The oxygen requirements in composts of different degrees of maturity are shown in Table 1; for comparison purposes, the table includes data on vegetation earth and farming soil.

TABLE 1. Oxygen requirements of composts of different degrees of maturity, in $mm^3/g \cdot hr$

1. Fresh refuse (0-day old)	18.2	
2. Fresh refuse (7-day old)	115.1	
3. Fresh refuse (10-day old)	176.3	
4. Fresh compost (4-week old)	284.6	
5. Nearly half-ripe compost	54.0	
6. Half-ripe compost	47.0	(Each value represents the average of
7. Nearly ripe compost	30.2	ten separate determinations)
8. Ripe compost	9.0	
9. Vegetation earth (compost: sand: peat = 2:1:1)	37.5	
10. Farming soil	22.1	

The table shows the oxygen requirement of freshly-ground refuse (1) to be very low. Seven-day old refuse, however, has a high O_2 requirement which rises to 284.6 mm^3 in 4-week old fresh compost. Composting plants supply this fresh compost as mulch compost; it is clear that such compost should be dug into the soil only superficially, to satisfy its high oxygen requirement.

The oxygen requirement drops considerably with increasing maturation. Half-ripe composts need 47 mm^3 O_2 per hour, and ripe composts only 9 mm^3. This low O_2 requirement of ripe compost is due mainly to the fact that the decomposition of organic matter is nearly completed and the microorganisms are no longer active. The microorganisms that colonize only slowly in ripe compost, can later also be found in the farming soil. This is borne out by unpublished investigations which revealed different fungi spectra in composts of different degrees of maturity.

Vegetation earth (9) with an oxygen requirement of 37.5 mm^3/hr carries various fungi, mainly of the kind that can be found also in healthy and active soil: different Penicillium species, Mucoraceae, Fungi Imperfecti. Bacteria are also present, colonizing the biologically equilibrated soil like the mentioned fungi.

Four composts of various degrees of maturity, with 45 and 65% water content, were subjected to further tests. Table 2 gives the results of the relevant breathing measurements.

TABLE 2. Oxygen requirements of four composts of different degrees of maturity and different water content. Values in mm^3 per hour and gram of material

	45%	60%
Fresh compost	263,3	305,9
Nearly half-ripe compost	54,0	53,8
Nearly ripe compost	32,0	35,1
Ripe compost	6,2	3,8

The figures represent averages of five measurements

Table 2 shows clearly that a higher water content favors the breathing of fresh compost. With advancing maturity of the compost the higher water content loses its effect and in ripe composts it even inhibits breathing. The high value of 305.9 mm^3 O_2 was measured in a material with heavy fungal growth colonized mainly by Streptomyces species and Cephalothecium roseum. Such material undergoes strong degradation of the organic matter, which raises its oxygen requirement.

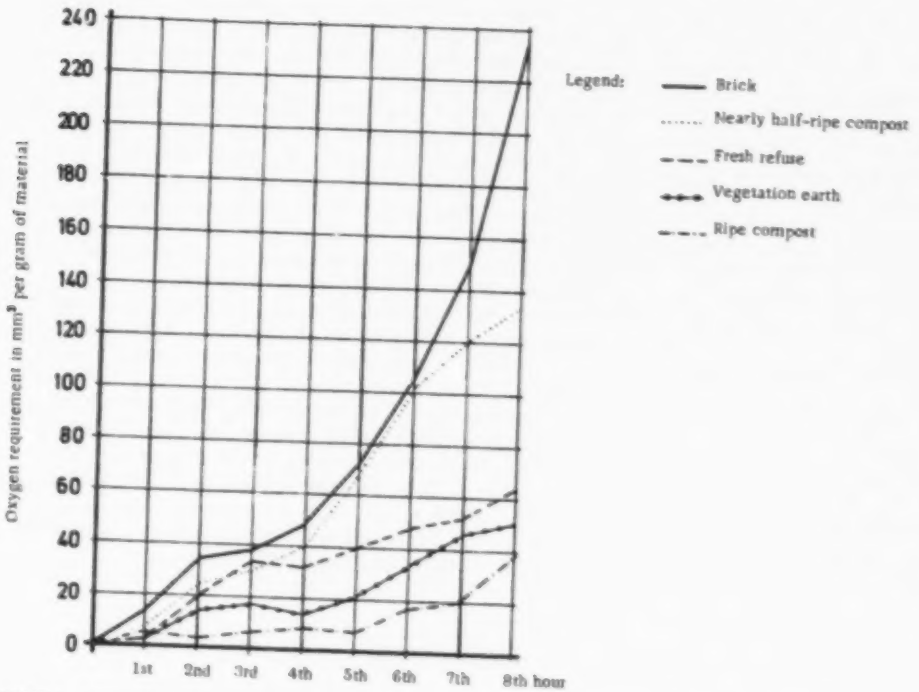

FIGURE 1. Resumption of oxygen consumption of differently ripe composts after 6 months' storage at 5% humidity

The resumption of breathing after 6-month preservation of each ripening stage at 5-percent water content (storage at 22°C with access of air) was to show whether the samples suffered any serious damage due to the long storage period under the specific conditions, and the length of time they required to resume normal breathing. Figure 1 shows the results of these tests.

Brick clay shows an oxygen requirement of 238.8 mm^3/g 8 hours after remoistening; this material shows slight breathing even in the first hour. The oxygen requirement of **nearly half-ripe compost** is almost equal to that of brick clay up to the 7th hour after remoistening, but subsequently clearly diminishes indicating advancing maturity. Only **fresh refuse** seems to suffer certain damage to the microorganisms. It resumes weak breathing only in the 2nd hour; however, its breathing remains far below that of the materials mentioned above, even after 8 hours. Fresh refuse obviously needs a longer start after remoistening for the microbial decomposition processes to get under way. In these tests, as with the previous ones, the oxygen requirement of **vegetation earth** surpassed that of **ripe compost**. Thus, no serious damage to the various compost forms is to be expected on account of the many months of storage at very low water content; the oxygen requirement of each sample after 8 hours corresponded to the relative degree of maturity.

DISCUSSION OF TEST RESULTS

The research on the oxygen requirement of maturing refuse compost shows it to be dependent on the relevant degree of fermentation. The highest measured value was 305.9 mm^3 per hour and gram of material. This requirement was found in a 4-week old fresh compost with 60% water content. A fast initial increase in the oxygen requirement with beginning composting is followed by a slow reduction in the half-ripe forms, down to a minimum oxygen requirement of ripe compost, which is below that of farming soil and vegetation earth (compost:sand-peat:= 2:1:1). Spohn and Kneer (op. cit.) found similar values by determining the amount of CO_2 released by differently ripe composts. Teensma (1964), using an oxygen electrode, found the oxygen requirement of fresh domestic refuse to be twelve times as high as that of well fermented compost. The writer's measurements revealed an oxygen requirement by fresh compost 30 times that of ripe compost.

Table 2 clearly shows the importance of the water content in optimum composting. A 60-percent water content favors the breathing of fresh compost, but inhibits that of ripe compost. Spohn and Kneer (op. cit., p. 69) also indicate that ripe compost is best stored at a low water content.

The rapid increase in oxygen requirement owing to remoistening after extended near-dry storage shows that no damage is done to the microorganisms that are active in the compost. The composts examined showed normal breathing again after 8 hours. Certain surviving forms in the compost are likely to become active again under the effect of higher water content, as is known from microrganisms in the upper layers of farming soil. Use is made of these conditions wherever the preparation of brick clay helps obtaining storable mulch compost.

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STUDIES ON THE COMPOSITION AND COMPOSTING OF DOMESTIC REFUSE IN CAIRO

By Abd-el-Malek, A.I. Naguib, and M.A. Guirguis*
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of the U.A.R.

At the request of "Société des Engrais Organiques" in Shoubra, Cairo, the National [Egyptian] Research Center examined the compost produced by the company from city refuse. The purpose of the examination was to establish whether the final product was mature enough and could be utilized without danger of nitrogen fixation. The composition of the refuse and compost, in particular their carbon and nitrogen contents, were to be investigated.

MATERIAL AND METHODS

The refuse submitted for examination was collected from the Rod-el-Farag and Shoubra districts. It included produce-market refuse, domestic refuse and street sweepings, as well as small amounts of street sweepings from the city quarters of Boulak and Zamalek and from downtown. The nonhomogeneous material contained dust, sand, street and produce-market refuse, animal feces, carcasses, wastes from stores and workshops, garden rubbish, rocks and rubble, etc. Upon delivery by trucks, the raw refuse was filled at random in sacks of ca. 100 kg, and weighed. For the mechanical analysis the material was screened by means of a coarse mesh (ca. 1-cm) sieve; the fine fraction C was thus obtained. Nondecomposable and utilizable materials, e.g., metal, glass, china, ceramics, rocks, rags, bones, etc., were picked out of the coarse fraction, yielding fraction A. The remaining coarse fraction B was decomposable. Each fraction was weighed and its proportion calculated.

Portions of 100 kg were rapidly sorted out for chemical analysis and the clearly nondecomposable and utilizable materials were removed as fraction A. Two ten-

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kilogram samples of the rest were filled in polyethylene bags and immediately taken to the laboratory, where the remaining parts of fraction A were sorted out and large pieces crushed to the size of 1—3 cm. Four parallel samples of approximately 100 g were dried for 24 hours at 105° C and their water content was determined. The dry material was comminuted and mixed, and used for the determination of organic carbon. Another portion was mixed with a 0.02 n sulfuric acid solution to prevent evaporation of ammonia, dried for 24 hours at 70° C, communited and utilized for nitrogen determination. Total-N was determined by Kjeldahl's method (A. O. A . C. 1955). The distillate was absorbed in boric acid (Ma and Zuzaga, 1942) with bromocresol green—methyl red as indicator (Montasir, Moustafa and Elwan, 1959).

Organic carbon was determined as follows: a few ml concentrated hydrochloric acid were added to 5 g of pulverized material in a tared porcelain crucible to decompose carbonates. The following day the crucible was dried for 24 hours at 105° C and, after weighing, heated for 10 hours at 750° C in a muffle furnace. The organic-C content was then calculated on the assumption that carbon constituted 58% of the organic matter. The wet-combustion method of Walkley and Black (1934) was used occasionally to determine carbon in the fine fraction; sodium fluoride was added for accurate determination of the titration end point.

RESULTS

Kind and composition of the refuse were examined over a 3-year period by 135 analyses. The results are shown in Table 1.

TABLE 1. Average values of mechanical analysis of fresh refuse

Month	Number of samples	Fraction A %			Fraction B %			Fraction C %			Year
		Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	
Jan.	7	19	10	23	61	47	74	21	16	31	1961 + 1962
Feb.	12	21	19	24	61	55	65	18	14	23	1961 + 1962
March	28	22	15	33	59	48	69	19	15	24	1960 + 1962
April	11	20	19	24	63	55	66	17	15	21	1960 + 1962
May	14	21	16	29	59	54	64	20	15	25	1960 + 1961 + 1962
June	12	23	21	26	58	50	63	19	16	24	1962
July	7	21	16	24	60	55	69	19	14	25	1961 + 1962
Aug.	15	17	15	20	67	58	74	16	11	24	1960 + 1961
Sept.	7	16	14	21	69	56	75	14	11	23	1961
Oct.	3	15	11	18	70	60	75	15	8	24	1961
Nov.	4	17	15	17	70	68	72	13	11	15	1961
Dec.	15	22	15	33	59	47	66	19	16	26	1959 + 1961
Average values		19	10	33	63	47	75	18	8	31	

A = nondecomposable and utilizable material
B = coarse decomposable fraction
C = fine decomposable fraction

Apart from utilizable mat[illegible]ials, the nondecomposable matter (fraction A, 10—33% of an average 19% o[illegible]. the refuse) contained wood, glass, metal, tin cans, and considerable amounts of rubber, plastics, bones, ceramics, rocks, leather, baskets, mattresses, etc.

Of the decomposable matter (fractions B and C) the coarser fraction B was the largest (45 to 75% at an average 63% of the refuse). Seasonal fluctuations were slight, with a tendency to higher values in August through November, i.e., in the hot season, when vegetable and fruit consumption is high. In that period opuntia fruits, roast corn, muskmelon, water melon, lettuce, etc., are eaten in the open in the U. A. R., and the street sweepings contain quantities of such refuse. In spring and summer this fraction also includes much residue of apricots, peaches, muskmelons, grapes, figs, opuntia fruits, mangoes, guavas, dates, bananas and pumpkins; in fall and winter it includes citrus fruit and sugar cane. The most frequent vegetables are cabbage, cauliflower, radishes, potatoes, spinach, lettuce, peas and carrots.

In every season of the year, the refuse contained considerable amounts of packing material, such as rice straw, paper, wood shavings, etc. Animal products included feathers and refuse from chicken farms and fisheries, and sometimes also carcasses of small animals (mice, rats, cats, birds, etc.).

The fine fraction obtained by screening consisted mainly of finely distributed organic matter of animal origin, such as horse and ass feces, and plant residue and earth. The ratio of the fine fraction to the coarse, decomposable part was fairly constant all the year round, fluctuating between 8 and 31% (average 18%). In general, the values of all three fractions showed no seasonal differences.

CHEMICAL ANALYSIS OF THE REFUSE

TABLE 2. Results of chemical analysis of fresh refuse, fractions B + C

Sample	Season	Water content, %	% of dry matter		C/N
			organic C	total N	
1	Winter	56.8	39.3	0.64	61.0
2		53.5	39.8	0.70	56.8
3		51.5	41.2	0.74	55.7
4		50.9	22.6	0.72	31.3
5	Spring	52.4	31.9	0.76	42.2
6		18.6	27.1	1.08	25.1
7	Summer	40.0	35.4	0.68	51.8
8		27.6	31.9	0.65	49.1
9		28.3	29.9	0.68	44.0
10		29.4	24.4	0.78	31.3
11	Autumn	50.2	28.9	0.83	35.0
12		35.3	29.0	0.87	33.3
13		39.9	32.5	0.96	33.9
14		30.6	24.8	0.88	28.2
15		25.0	24.1	0.92	26.3
16		45.2	36.6	0.77	47.5
Average values		39.7	31.2	0.79	40.8
Range		18.6-56.8	22.6-41.2	0.64-1.08	25.1-61.0

Table 2 shows the results obtained from 16 samples taken at random in the course of a year from fractions B and C; they include water content, organic C, total N and C/N ratio. Seasonal differences are noticeable. The water content was low in summer and high in winter, the averages being 53.2% in winter, 37.7% in fall, 35.5% in spring and 31.3% in summer. Only the winter value differed

significantly from the overall mean value of 39.7%, which can be explained by the considerably lower temperatures. The organic-C values fluctuated between 22.6 and 41.2% (average 31.2%), the nitrogen content varied between 0.64 and 1.08% (average 0.79%). The C/N ratio fluctuated between 25 and 61 (average 40), the higher fall and winter values being due probably to larger shares of sugar-cane and citrus-fruit peels.

The results obtained from 15 samples of fine fraction C are as follows:

water content 10.3%
organic C 14.3%
total N 0.48%
C/N 29.5%

The still considerable amount of carbon (determined here by the Walkley-Black method) indicates a high organic matter content.

COMPOSTING PROCEDURE

At the Shoubra plant the refuse is dumped into fermentation tanks according to the Boggiano-Pico process, and the nondecomposable and utilizable material is sorted out after composting. Unfortunately, some of the machines failed shortly after being put into operation and the final product could not be comminuted. Ten cylindric fermentation silos (18 m diameter, 5.8 m height, maximum capacity c. 1,200 tons each) were available. Three tanks were filled in about 13 days.

TABLE 3. Results of refuse compost analyses

Month	Water content, %	% of dry matter		C/N
		organic C	total N	
Jan.	50.92	28.15	0.66	42.84
Feb.	56.50	25.40	0.60	42.33
March	39.23	20.92	0.52	40.00
April	50.30	23.14	0.71	32.55
May	42.00	30.00	0.94	31.91
June	51.00	23.40	0.78	30.00
July	39.76	23.99	0.82	29.18
Aug.	36.60	24.20	0.83	29.15
Sept.	39.00	25.40	0.93	27.31
Oct.	38.00	21.20	0.92	23.00
Nov.	52.00	25.00	1.14	22.00
Dec.	46.62	30.28	0.89	33.86
Average values	45.11	25.09	0.81	32.01
Range	36.0-56.5	21.2-30.3	0.52-1.14	22.0-42.8

Meanwhile the material was constantly leveled and sprinkled with waste water from the plant. After filling, the silos remain closed during the average composting period of 36 days, but water is added when needed (a total of 188 m^3 per period). Water drains through the bottom of the fermentation-tank. Compressed air is fed through two openings at the base and at the top part of each tank at half-hour intervals for a total of 6 ½ hours. Unfortunately, air temperature and volume could not be measured accurately. The compost is carried by conveyor belts to

the place where nondecomposable and utilizable materials as well as coarse matter are discarded by hand, the nondecomposable portion thus being reduced from 19 to about 3.5%. The compost is then stored, undergoing an additional decomposition process during storage.

Table 3 shows the analyses results of 12 samples taken at random during the year. The organic-C values again show a comparatively high content of organic matter, and the figures for the C/N ratio are high too. On the whole, the quality of the product was rather bad; it was lumpy, wet in parts, dry and not decomposed in others.

TABLE 4. Results of analyses of stored refuse compost

Sample	Storage duration, weeks	Water content, %	% of dry matter		C/N
			organic C	total N	
1	2	45.14	24.23	0.59	40.80
2	4	32.90	21.90	0.75	29.12
3	7	35.48	22.41	0.84	26.84
4	9	30.40	20.94	0.82	25.44
5	9	31.57	19.04	0.79	24.22
6	15	17.86	15.17	0.88	17.28

EFFECT OF STORAGE

Subsequent storage leads to a reduction of the C/N values after a considerable lapse of time. Table 4 shows relevant figures derived from random samples which do not correspond to the same initial material. Therefore a special experimental windrow of 3—4 m length, 1.8 m height, 2 m width at the bottom and 0.75 m width at the top, was deposited for 94 days. For every analysis eight 10-kg samples taken from different 40-cm-deep spots were mixed. The results (Table 5) show that the values gradually decrease and stability is attained after 2 months.

TABLE 5. Results of analyses of compost deposited in the experimental windrow

Storage duration, days	Water content, %	% of dry matter		C/N
		organic C	total N	
0	42.63	25.38	0.93	27.28
7	38.92	24.92	0.92	27.00
14	32.82	22.18	0.86	25.91
65	20.17	18.15	0.96	18.96
94	12.98	17.06	0.98	17.40

COMPOSTING UNDER CONTROLLED CONDITIONS

To obtain data concerning the effects of different factors on composting, one silo was sealed and thermometers were inserted at heights of 1.5 and 3 m, and at a distance of 4 m from the wall. Filling, composting process, and air and water additions were kept under observation in seven periods extending over 14

months. Fresh material was wetted at the filling and samples were taken daily. These were combined and thoroughly mixed to form one sample whose water content, organic C, and nitrogen were determined. The same was done when emptying the silo.

TABLE 6. Experimental and analysis results of seven composting periods under controlled conditions

Period	Water addition		Aeration,	Duration, days			Temperatures	
	initially	additionally	hours	filling	composting	emptying	min.	max.
1	293	20	40.5	20	74	13	47.5	67
2	268	—	15	15	36	12	49	63
3	266	—	—	15	30	17	43	76
4	87	—	—	11	13	18	47	75
5	245	—	6	13	18	10	44	70
6	256	10	6	14	17	14	42	63
7	240	—	6	17	41	17	46	70

	Water content, %		% of dry matter				C/N	
			organic C		total N			
	raw	composted	raw	composted	raw	composted	raw	composted
1	40.97	50.55	25.73	23.40	0.76	0.78	33.72	30.19
2	18.59	51.66	27.07	25.00	1.08	1.14	25.07	21.86
3	29.42	38.28	24.42	21.08	0.78	0.72	30.30	29.11
4	39.94	42.24	32.46	30.04	0.96	0.94	33.81	32.51
5	24.96	38.32	24.05	21.24	0.92	0.92	26.22	23.06
6	50.24	56.48	28.88	24.23	0.83	0.83	35.00	29.12
7	27.64	35.82	31.85	25.43	0.65	0.60	49.00	42.27

The figures in Table 6 indicate no clear correlation. Temperature maxima are highest in the test periods 3 and 4 without aeration, but the organic-C decomposition rates and the C/N values are rather low and do not differ greatly under widely varying aeration and humidity conditions. The maximum temperature apparently varies inversely with the water content of the initial material. On the whole, the temperature rose to 50° C within the first 1—5 days, reaching 60° C within 17 days, i.e., the decomposition process began during filling. The very small reduction of the C/N values in periods 3 and 4, when temperatures exceeded 65° C for more than half the time, indicates that optimum decomposition temperatures are 55—63° C. It is obvious, however, that refuse is not readily decomposable.

DISCUSSION

Sampling difficulties due to nonhomogeneity of the material must be taken into account when assessing the measured values. Certain limit values can, nevertheless, be determined: e.g. 22.6-41.2% organic C, 0.64-1.08% nitrogen and 19% nondecomposable substances in the fresh refuse. Silo composting yields an unstable product, which can still heat up greatly and must therefore be stored for at least another 2 months, until it reaches stable C/N values below 19. The nitrogen content, however, plays a much lesser role in difficultly decomposable matter

(Mattingly, 1956), since only oxidizable carbon can cause a corresponding nitrogen fixation. A slow reduction in the C/N value of refuse may therefore be expected. Coarse structure also slows down decomposition. Initial comminution would have positive effects, as would an aerobic decomposition process (Karim and Chawdhury, 1958), but this would encounter great difficulties in the silos of the Shoubra plant. An admixture of readily-soluble nitrogen should also be tested. The experiments on the effect of humidity, aeration and composting duration yielded no clear results. Artificial aeration and moistening in the 1,200-ton silos are practically impossible owing to the formation of channels.

SUMMARY

The physical and chemical composition of the refuse from the city of Cairo was studied during 12 months. Mechanical separation yielded three fractions:

nondecomposable substances and coarse materials, 10 to 33% (average 19%): glass, metal, ceramics, rubber, plastic materials, wood, baskets, etc.;
coarse decomposable matter, 47 to 75% (average 63%);
fine fraction, 8 to 31% (average 18%).

The water content of refuse fluctuates between 18.6 and 56.8% (average 39.7%). After exclusion of the nondecomposable fraction the chemical analysis yields the following values:

organic carbon	22.6—41.2%	(average 31.2%)
total nitrogen	0.64—1.08%	(" 0.79%)
C/N	25.1—61.0	(" 40.8)

Fresh compost produced in silos at the Shoubra plant has the following composition:

organic carbon	21—30%	(average 25%)
total nitrogen	0.5—1.1%	(" 0.8%)
C/N	22—43	(" 32)
water content	36—57%	(" 45%)

The compost continues to ferment during the subsequent storage and a stable product is obtained only after 2 months. The composting process could not be influenced by artificial aeration and moistening.

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RECENT RESEARCH ON REFUSE DISPOSAL IN THE U.S.A.

By P. Descroix, Secretary-General of A.G.H.T.M., Paris

For two years now, efforts have been made in the U.S.A. to eliminate random disposal of solid waste. The Public Health Service (a branch of the U.S. Department of Health, Education and Welfare) in cooperation with its central authority, the National Center for Urban and Industrial Health, has spent over $2.1 million within 18 months on research in connection with its Solid Waste Program.

Colleges may claim such subsidies for training specialists. The universities of Florida in Gainesville. and West Virginia in Morgantown have been granted a total of $100,000 for scholarships.

States may also receive contributions for overall studies of waste disposal in their areas. So far, twenty-five states have availed themselves of this assistance and have each received subsidies amounting to about 50% of the costs, which adds up to $940,000. According to Leo Weaver, Head of the Solid Wastes Program, the main purpose of these studies is to form regional corporations. Responsibility for the disposal of solid waste is to be assumed by organizations large enough to carry out this task efficiently.

Los Angeles city and area receive a grant of $^2/_3$ of their $860,000 expenses for a three-year research program on incineration methods that would meet the strict air-hygiene requirements with a minimum of technical expenditure. It is hoped that this will be achieved by means of a new type of furnace. Under the operating conditions of a large furnace, the prototype will have a capacity of 100 to 150 tons per day.

Florida's experimental fruit-growing station in Lake Alfred was granted a subsidy to study the utilization of fruit residue and fruit sludge in the production of citric acid. Requirements for this substance by the food, drinks and drugs industries in the U.S.A. amount to 40–45,000 tons per annum. An attempt is being made to produce citric acid and animal feed simultaneously by admixture of molasses and fermentation with the fungus Aspergillus niger.

The Air-Pollution Research Center of the University of California at Riverside receives support in its study of the control of ill-smelling gases in cattle stuffing farms. Hazards to man from these gases and the treatment of animal excreta are being investigated at the same time. The Purdue and Urbana universities receive grants for their research programs concerning the decomposition of liquid farmyard manure and excreta, and elimination of the nuisance effects of ill-smelling gases. Aeration and stabilization tanks are to be tested by means of chlorine compounds.

The University of Maryland receives $52,000 as a first annual instalment for an experimental project on the utilization of tree branches, leaves, green and overripe tomatoes as fodder. Simultaneously tests are to be made on processing for ensilage of the extraction of proteins for food, and the production of fungicides or pharmaceutical substances. Similarly, the reutilization of other vegetal and animal waste products is to be studied.

The American Public Works Association was granted $178,000 to study the possibilities of removing domestic refuse by railroad to controlled tipping sites. The New York Central System Railroads Company will help solving the problems of rolling stock, transfer stations, containers, and compacting of the refuse.

Of the other research grants we mention the following:

$110,000 to the University of Auburn, Ala., for the evaluation of compost and sewage sludge in agricultural use.

$18,000 to the Air Pollution Research Center of the University of California for studying possibilities of composting lignified agricultural wastes.

$30,000 to the Georgia Institute of Technology for developing a mathematical model to investigate waste disposal problems in large cities.

$21,000 to the Rutgers University, New Brunswick, for the study of fruit and vegetable resistance to decay by a better insight into the action mechanism of pectinesterase.

$80,000 to the Rutgers University for studying the maximum amount of chicken manure that can be utilized for fertilization and soil melioration.

$30,000 to the Manhattan College of Engineering for studying acceierated decomposition of cellulose.

$42,000 to the University of Pennsylvania for investigating refuse collection and transportation.

Other research projects concern the conversion of refuse to fodder and problems of controlled tipping.

DISCUSSION CORNER

ON THE PROFITABILITY OF THE USE OF REFUSE COMPOST

A reply to the chapter "Profitability from the Standpoint of the Compost Consumer" in Issue 2 of the series "Processing and Utilization of Municipal Refuse" by D. Stickelberger (Voith Müllex GmbH, Heidenheim 1967)

By Dr. J. Geering, Eidg. Landw. Versuchsanstalt Zürich-Oerlikon

The series mentioned above is intended for public officials and others who make decisions in the field of waste disposal, to inform them about the marketing possibilities of refuse compost.

The author (D. S.) tries to clarify the profitability problem, which is decisive in the utilization of refuse compost, from the consumer's point of view on the one

hand, and from the standpoint of the national interest, on the other. As far as the consumer's interests are concerned, D. S. arrives at the following conclusion in the relevant subparagraph (pp. 36 – 39): **"Thus, as long as the utility value of fertilization with city compost cannot be applied to the entire cost structure, calculations will remain unsatisfactory. From experience gained so far, it is clear, however, that the use of compost can help balance the various cost factors profitably, provided prices and transportation conditions do not exceed reasonable limits."**

It is left to the reader to answer the question of profitability, which in the long-term view undoubtedly will be decisive for the marketing possibilities of refuse compost. It is exactly on this point that the reader needs to be informed to avoid erroneous speculation. No test results or figures are given by D. S. in support of the view that "experience gained so far" proves the use of compost to be profitable. On the other hand, in an entire subchapter on the compost consumer's point of view, he criticizes our economic interpretation of our own test results (On the Agricultural Utility of Refuse, According to Results of Laboratory and Field Tests. – Schweiz. Landw. Forschung, No. 3, pp. 277 – 317. 1964.).

The need for information on planning of refuse utilization plants prompted us to accept only provisionally – as explicitly mentioned – the available results of field tests that have been carried out with various wastes, since 1949, 1955 and 1957, respectively. In another series of field tests with crude refuse and refuse compost initiated simultaneously in 1963 by the associated agricultural experimental centers Lausanne, Liebefeld-Bern and Zurich-Oerlikon in agreement with the Federal Institute for the Distribution and Maintenance of Water Resources and Purification of Sewage (EAWAG), Zurich, it is aimed at studying – as in earlier tests in combination with or without mineral fertilizers – the overall effects of the use of compost, which can be established only by experiments and investigations over a long period of time. In accordance with our scope, this test series is concerned with common agricultural farming and forage-growing in Switzerland. The validity of the test results will be limited to these spheres, of course, and will exclude vegetable growing, wine growing, tree nurseries and other intensive cultivations, where different criteria apply.

We agree with D. S. that our provisional statement reflects an incomplete picture. **Moreover, it gives as a temporary rule of thumb that refuse compost can be utilized in general Swiss agriculture only if it is delivered free of charge to the place of consumption.** For the compost producer this particular market will not constitute a means of **utilization** of the compost, but only a means of disposal.

We cannot, however, accept the objection by D. S. to our view of the situation. If we are to comment on it we should like to limit ourselves strictly to the subject under discussion: "Profitability from the standpoint of the compost consumer." Profitability and pertinent calculations, in our opinion, are but commercial considerations of a business matter. Expenditure entailed by a "business transaction," in our case compost utilization, is compared with receipts and assets of any kind. On the credit side belong the (initially hardly apparent) effects of compost on soil structure, water retention capacity, nutrient storage capacity, biological soil activity, etc., briefly any soil melioration (on which many long-winded chapters can be written that do not contribute anything to practical results). Except for a possible saving in expenditure (on soil cultivation, mainly for intensive cultures, which is outside our scope), soil melioration, if at all justified practically, should be evident by correspondingly larger yields, as a result of improved soil fertility. As long as "cost structure" and "cost factors" cannot be assessed as either expenditure items or returns, they cannot be taken into consideration in the profitability calculations of compost utilization by a farmer who must act in the sense of a private entrepreneur.

Divagating to the scare of excessive nitrogen fertilizing and its damaging effect on the quality of plant products and the dangers to health of man and animals, D. S. finds further reason to criticize the interpretation of our experimental results. The comprehensive experimental data presented offer no reason, however, for constructing any such "connection" with the abuses of commercial fertilizer application.

There are differences of opinion also concerning the value of "trace elements." We would like to raise this question: Can anyone prove, even very approximately only that refuse compost always contains the optimum mass ratios required by the plants, and no poisonous overconcentrations from fortuitous industrial wastes? In our local conditions, boron and manganese are the two main micronutrients of well-known practical importance. As regards boron, experience has shown that an approximately normal application of 50—100 tons compost per hectare (5 to 10-ton waggons, i.e., a small freight train) can cover the requirement of beets that are so sensitive to boron deficiency. However, the same result can be obtained by using 5 to 10 kg/ha common boric acid (a handbag-full at 10 to 20 SR.), without any ballast or dubious secondary components. As for manganese, the "refuse disease" must be mentioned (conf. e.g. L. Gisiger, Die Kehrichtkompostbereitung und an sie zu steilende Forderungen*).—Schweiz. Landw. Monatshefte, No. 36, pp. 385—396, 1958), which is a symptom of manganese-deficiency due to excessive garbage fertilization. These two micronutrients show that trace elements are often considered rashly as particularly valuable components of refuse compost, although it is not yet known under what conditions and in what amounts many of them might have favorable, damaging, or even poisonous effects.

In this connection, we are pleased to mention that in Swiss agriculture mineral fertilizers are used only as supplement, to an extent of about 10% of the total consumption, owing to the plentiful supply of dung and liquid manure from livestock breeding farms. Most of the necessary mineral nutrients, including micronutrients, are therefore in constant circulation, thus preventing depletion. The natural mineral resources of the geologically young Swiss weathering soils also help eliminate the problem of mineral deficiency which is prevalent in wasteland cultivation of weathered quartz-sand soils.

There certainly is no universally valid evaluation of refuse compost. Any criticism of profitability considerations for a particular application will therefore be wrong, if it is based on other applications. Evaluation of refuse compost for application to intensive cultures or to wasteland cultures was outside our scope.

* [Garbage Composting and Pertinent Requirements.]

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